Overview and Categorization of European Biogas Technologies

- Receipt, storage, pre-treatment and handling of feedstock -

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DiBiCoo – Digital Global Biogas Cooperation

Grant Agreement N°857804

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Executive Summary of D2.2

The following document gives an overview of existing European biogas technologies.

The structure following the introduction section about Anaerobic Digestions (AD) follows the biogas processing logic: from feedstock storage on site and necessary pre-treatment to the various digester technologies. Special chapters on important elements of any biogas plant are elaborated in detail (e.g. on measurement, control and regulation technologies).

Upgrading biogas to biomethane quality as well as various application of Biogas are introduced (e.g. its GHG mitigation potential, as Combined Heat & Power (CHP) plants).

Due to the huge amount of existing information and knowledge on this topic it may occur that not everything is included or considered extensively. We propose this deliverable as a solid starting point getting to know about anaerobic digestion. This doesn´t replace special training courses and at least professional planning. In order to incorporate more relevant technologies and Biogas applications, some sections already outlined in this technology overview (e.g. on various pumps, pipes and valve types; or safety equipment) will be presented in an updated version later in October 2020.

The detailed descriptions of certain technologies are not implying any preference to a technology, service provider or device. Similarly, pictures including company names shall not be seen as a preference to any specific company or technology. It is done for visualization purposes only.

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Summary of the DiBiCoo Project

The **Digital Global Biogas Cooperation (DiBiCoo)** project is part of the EU's Horizon 2020 Societal Challenge 'Secure, clean and efficient energy', under the call 'Market Uptake Support'.

The target importing emerging and developing countries are Argentina, Ethiopia, Ghana, South Africa and Indonesia. Additionally, the project involves partners from Germany, Austria, Belgium and Latvia. The project started in October 2019 with a 33 months-timeline and a budget of 3 Million Euros. It is implemented by the consortium and coordinated by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The overall objective of the project is to prepare markets in developing and emerging countries for the import of sustainable biogas/biomethane technologies from Europe. DiBiCoo aims to mutually benefit importing and exporting countries through facilitating dialogue between European biogas industries and biogas stakeholders or developers from emerging and developing markets. The consortium works to advance knowledge transfer and experience sharing to improve local policies that allow increased market uptake by target countries. This will be facilitated through a digital matchmaking platform and classical capacity development mechanisms for improved networking, information sharing, and technical/financial competences. Furthermore, DiBiCoo will identify five demo cases up to investment stages in the 5 importing countries. Thus, the project will help mitigate GHG emissions and increase the share of global renewable energy generation. The project also contributes to the UN Sustainable Development Goals (SDG 7) for 'Affordable and clean energy", among others.

Further information can be found on the DiBiCoo website: www.dibicoo.org.

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List of Abbreviations

AD	Anaerobic Digestion
CHP	Combined Heat & Power
D	Deliverable
T	Task
SC	Steering Committee

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1 Receipt, storage, pre-treatment and handling of feedstock

Each biological process depends highly on ambient conditions but also on the feedstock being used. Therefore, it is very important to quantify and qualify the feedstock. In case feedstock is organic waste from households, catering etc., a pre-check on possible impurities is required in order to ensure that no substances will enter the digestion process that might inhibit the process. Depending on the source of feedstock the following steps are common:

- receipt, pre-check and weighing of feedstock
- pre-treatment
- storage
- handling and feeding into the digester

A weighing system and a small office to check the delivered feedstock is usually installed at the entrance of typical biogas plants. In order to determine the amount and quality of the feedstock the delivered charge is weighed and a sample to determine dry matter content and volatile organic solids is taken. In some cases, also the nutrient content will be determined. This data will be recorded and further used for the steering of the digestion process. Some plants also take retaining samples and store them for further testing or, if problems occur, for a post-check on inhibitors. In general, substrates can be divided in two groups:

a) substrates which usually have no impurities and do not underly animal by-product regulation
b) substrates which may include impurities (e.g. pathogen bacteria (meat), heavy metals, plastic) and may underly animal by-product regulation (1069/2011/EU)

Agricultural residues -except for manure- belong mainly to group a) and usually accrue in huge amount during harvesting season. Therefore, different types of storage systems are needed:

- stacked in halls if dry, bulky and not putrescent (e.g. straw)
- stored in not gas-tight silos or halls if dry, not stackable and not putrescent
- stored in gas-tight silos if wet, bulky and putrescent/ likely to rot. The most common technique to avoid rotting during storage is to silage the feedstock in vertical or horizontal air-tight silos. Depending on the moisture content, the feedstock and the used storage technique, the preservation is done by CO_2 or by a reduction of the pH value.
- stored in tanks if liquid and not putrescent

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Picture 1: top: office to check delivered feedstock and weighbridge, bottom left: automatic sampling-taking of delivered feedstock, bottom right: batch test determining the methane yield of specific substrates.

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Picture 2: Different types of storage systems: top left: not gas-tight silo, top middle: gas-tight silo where conservation is done with carbon dioxide, top right: air-tight silo where conservation is done through lowering pH value, bottom: air-tight clamp silo, where compression is done with heavy machinery like tractors or even snow groomers.

Picture 3: Straw stacked in bales.

Group b) of possible substrates that mainly underly additional animal by-product regulation, is usually delivered daily and, except for farm fertilizer, is possibly contaminated with different kind of impurities or even inhibitors. These substrates therefore underly completely different requirements after entering the biogas plant.

Feedstock from farms is usually delivered and fed directly into the digester. Only a very short storage time is foreseen for example for manure. Municipal organic waste is usually stored within waste bins before collected by special lorries on a weekly basis or even more often. Depending on the collection system, the waste bin will be directly cleaned after being emptied

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into the lorry by the collecting company or the waste bin will be transported to the biogas plant, emptied and cleaned there. Although many efforts are made to avoid food waste, sometimes food cannot be sold due to the exceeding expiration date. The best option then is to convert this organic waste streams into energy and use the digestate for nutrition. Companies from the biogas industry developed special devices to unpack and separate packing material or other impurities within one working step. If in Europe animal by-products are used as feedstock, sanitation requirements of animal by-product regulation need to be fulfilled (Table 1). Sanitation is usually done directly after acceptance and the substrate is usually pumped directly into the digester afterwards.

For substrate that might include impurities or needs to be crushed, a metal separation is done as a first step. Afterwards, different kinds of devices crush the substrate so that it can be treated more easily and to avoid damages.

Picture 4: Bunker systems for solid organic waste with two different conveying systems, left: screw conveyor, right: crane.

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Picture 5: Top left: organic waste bin from catering and households, right: collecting lorry for catering and household waste with integrated emptying and cleaning device, bottom: organic waste bin emptying facility at the biogas plant with a subsequent washing-bay.

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Picture 6: Metal separation is always the first step before further treatment, followed by crushing and further separation like sieving, separation through decanter or pulper.
Picture source for sieving and pulper; © Sutco Recycling Technik, Lohse Maschinenbau.

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Picture 7: Left: unpacking machine for expired food with automatic separation of impurities, right: sanitation devices installed in parallel for higher performance.

Picture 8: Steam explosion, left: continuously processed, right: batch system.

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Table 1: Possibilities to fulfil legal requirements for animal by-product sanitation of EU Animal by-product regulation and EU fertilizer regulation

European legal requirements for sanitation of animal by-products (1069/2011/EU, 1009/2019/EU)			
Digestion requirements	Hydraulic retention time of post-digestion	pasteurization	post composting
55 °C, > 24 h secured retention time	+ 20 d		
55 °C		+ 70 °C, >1h	
> 37 °C		+ 70 °C, >1h	
> 37 or 55 °C			70 °C + 3 days
> 37 or 55 °C			60 °C + 7 days
> 37 or 55 °C			55 °C + 14 days

Depending on the properties of the substrate and the digestion system, different systems are used for the transport of substrate within the biogas plant to the point of feeding into the digester. Most commonly used for the transport from the storage silo into the feeding system are wheel loaders, self-propelled distribution trailers, screw conveyors, conveyor belts and – if the substrate is liquid – also different kinds of pumps.

Picture 9: Self-propelled distribution loader.

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Picture 10: Substrate feeder systems for bulky and dry substrates: top left: with internal mixing screws, top right: feeding system with walking floor, bottom left: push floor, bottom right: scraper floor.

Picture 11: Feeding screw into the digester from the top. The feeding screw must always end below the liquid surface so that no biogas can escape.

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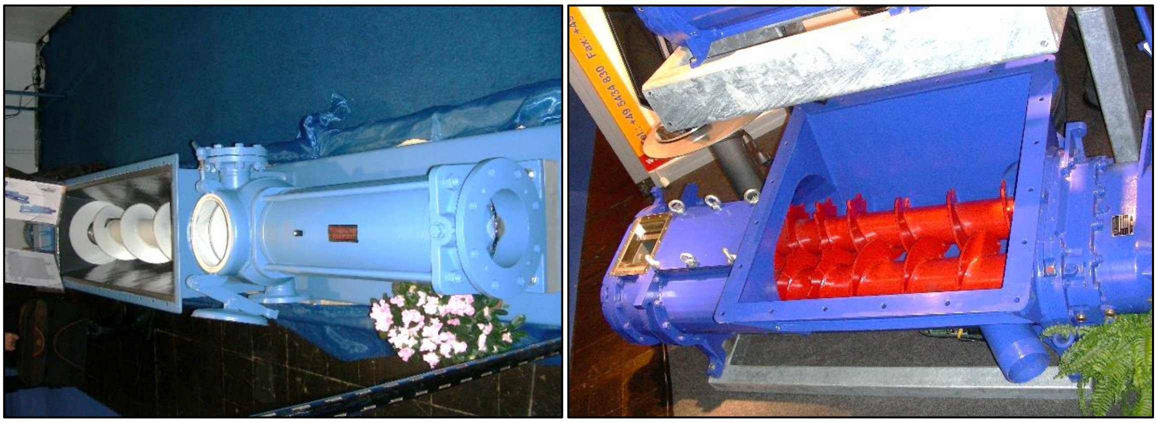
Picture 12: Substrate mixing tank followed by a feeding pump.



Picture 13: Pumps with a screw conveyor in front to mix solid and liquid substrate before pumping it into the digester, left: eccentric spiral pump, right: rotary piston pump.

The air of rooms where dangerous and often unpleasant odour can occur, must be ventilated, or collected and cleaned. This is usually done using a biofilter. The collected air is pressed from the bottom into the biofilter where bacteria degrade the odorous substances. Wood chips are usually used as bedding material for the bacteria. In order to ensure correct operation, the temperature, humidity and availability of nutrients must be controlled.

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Picture 14: Biofilter filled with wood chip as bedding material for odour substance degrading bacteria.

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